University of Manitoba

Department of Electrical & Computer Engineering
Graduate Course Outline

Fall 2021

ECE7440 T18 – Wavefield Imaging and Inversion In Electromagnetics and Acoustics

COURSE DESCRIPTION:

Microwave and acoustic imaging has various applications in engineering, geoscience, medicine, security and various others fields. At the core of these applications is solution of the inverse scattering problem: where we attempt to infer the sources of scattering from measurements outside of the scatterer.
This course provides introduction to the mathematical and numerical approaches to the solution of such inverse problems with a focus on microwave imaging on biomedical targets. Laboratories are used to reinforce the course material using computer programming exercises in MATLAB or C++ and provide students with ready-to-use solvers for practical problems in research.

COURSE OBJECTIVE:

To learn the theory, and be able to apply knowledge of inverse scattering problems.

PRE-REQUISITES:

No formal prerequisite, but note that course material has significant mathematical (integral solutions of partial differential equations) and programming content (MATLAB or C++ or Python as the student prefers).

CONTACT HOURS:

3-hours per week, plus 5 assignments.

COURSE CONTENT:

The following topics will be discussed:

- Review of basic electromagnetic theory
  - Maxwell's equations
  - Transverse Magnetic and Transverse Electric scattering
  - Green's functions
- Inverse Problems
  - Classification of inverse problems (inverse source/scattering and their relationship)
  - Formulation of forward and inverse scattering problems (integral and differential forms)
  - Inverse problem solution (existence and uniqueness, minimum norm, least squares and regularized least squares solution)
- Inversion Methods
  - Classification of inversion methods
  - Direct Approximate methods (Born Approximation, Extended Born Approximation, 2D Diffraction Tomography)
  - Direct Iterative and optimization methods (Distorted Born Iterative Method, Contrast Source Inversion method)

HOMEWORK:

There are 5 labs/assignments.

TEXTBOOK:

[1] Notes provided by the instructor.

[2] M. Oristaglio and H. Blok, "Wavefield imaging and inversion in electromagnetics and acoustics", Delft University, Lecture Notes, 1995 (available in pdf form from instructor upon request).

[3] J. Richmond. "Scattering by a Dielectric Cylinder of Arbitrary Cross Section Shape," IEEE Trans. on Antennas and Propagation, 1965.

[4] C. Gilmore. "Towards and Improved Microwave Tomography System," Ph.D. dissertation, Dept. Elect. Comput. Eng., Univ. of Manitoba, 2009.

[5] Xudong Chen, Computational Methods for Electromagnetic Inverse Scattering, Wiley-IEEE, 2018

GRADE ANNOUNCEMENTS:

Grades for this course will be announced by January 2021

EVALUATION:

Your final course grade is determined by your performance in the components list below in the Evaluation Table (assignments, quizzes, and a final examination. Students must receive a minimum of 50% on the final examination and must complete and pass all components in the course in order to be eligible to receive a passing grade.

Each component is weighted as follows:

COMPONENT	NO	VALUE %	TOTAL VALUE	DETAILS / ADDITIONAL INFO
Assignments	5	30%	30	
Quizzes	5	20%	20	In class quizzes.
Final Examination	1	50%	50	
TOTAL			100	

GRADE SCALE:

LETTER	MARK	LETTER	MARK	LETTER	MARK	LETTER	MARK
A+	95-100	B+	80-84	C+	65-69	D	45-54
A	85-94	B	70-79	C	55-64	F	<45

INSTRUCTOR INFO:

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VOLUNTARY WITHDRAW:

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REQUIREMENTS/REGULATIONS

Student Responsibilities: It is the responsibility of each student to contact the instructor if he/she is uncertain about his/her standing in the course and his/her potential for receiving a failing grade. Students should also familiarize themselves with Sections 4 and 6 of the Regulations dealing with, among others, incomplete term work, deferred examinations, attendance and withdrawal, etc..

Lectures: Attendance at lectures is essential for successful completion of this course. Students must satisfy each evaluation component in the course.

ACADEMIC INTEGRITY

Students are expected to conduct themselves in accordance with the highest ethical standards of the Profession of Engineering and evince academic integrity in all their pursuits and activities at the university. As such, in accordance

with the General Academic Regulations and Requirements of the University of Manitoba, Section 7.1, students are reminded that plagiarism* or any other form of cheating is subject to serious academic penalty (e.g. suspension or expulsion from the faculty or university) regardless of media

- examinations
- assignments
- laboratory reports
- term exams

A student found guilty of contributing to cheating in examinations or term assignments is also subject to serious academic penalty

Please refer any questions regarding Academic Integrity to your course instructor.

***Plagiarism:** to steal and pass off (the ideas or words of another) as one's own; use (another's production) without crediting the source